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PROGRESS REPORT

1958 PHASE OF PLEASANT CREEK WATERSHED RESTORATION EVALUATION STUDY

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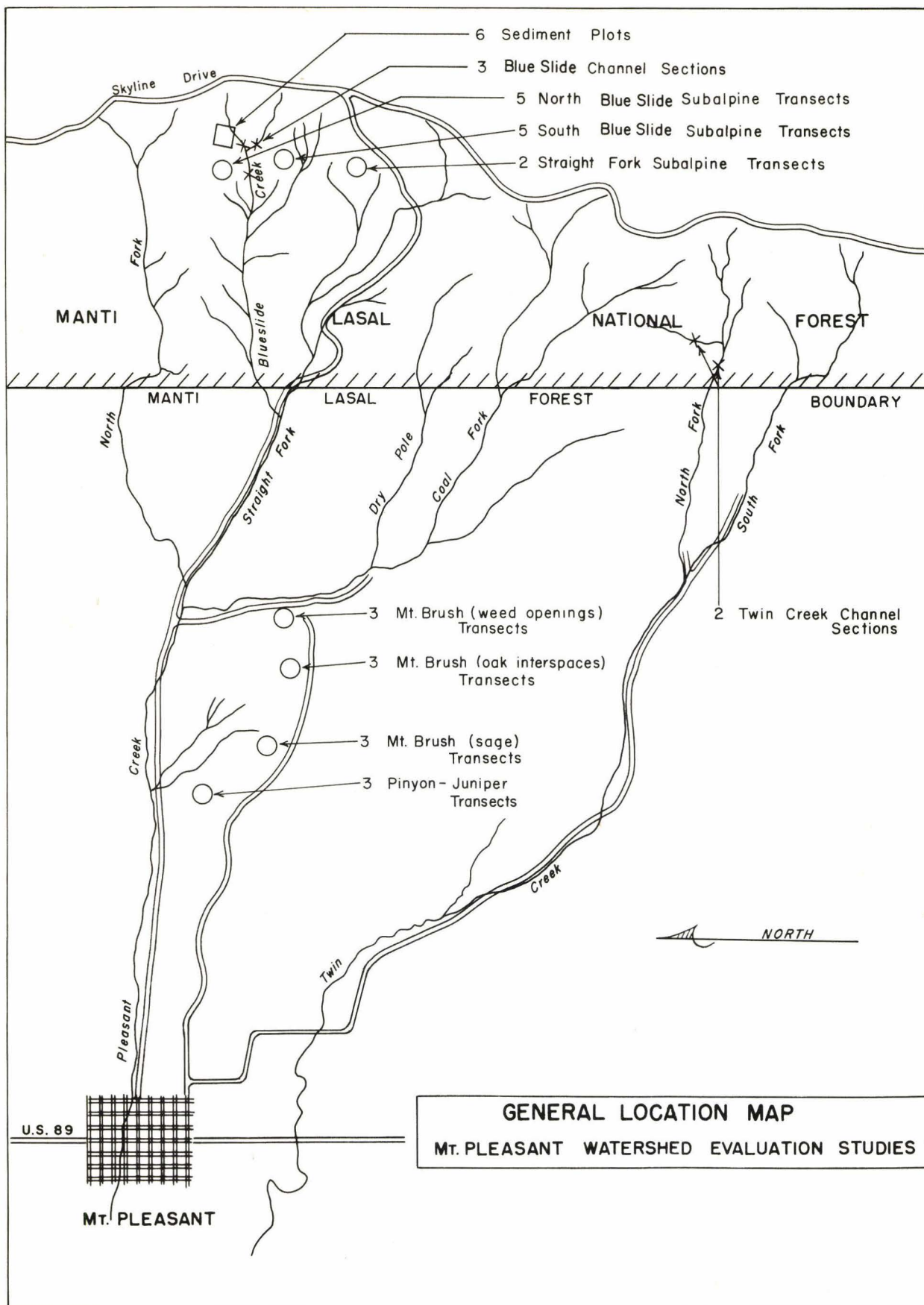
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INTRODUCTION

The Pleasant Creek watershed was among the first watersheds in the United States to be treated under provisions of the small watershed Demonstration Project Item of the Agricultural Appropriation Act of F.Y. 1954 (Public Law 566). Restoration treatments began in 1950 under the provisions of Public Law 46, and in September 1953 work on this project was resumed under provisions of Public Law 566. Because this watershed was one of the first to receive treatment under this program, an evaluation of the benefits was a definite part of the project and funds were allocated for this purpose. The Intermountain Forest and Range Experiment Station was assigned responsibility for planning and supervising a study to evaluate effects of the upstream treatments in cooperation with the Manti-LaSal National Forest and the Soil Conservation Service. This study involves comparison of the 1955 pretreatment measurements of infiltration, slope and channel erosion, ground cover, and herbage production with those of 1958, 3 years after treatment. Data obtained during the 1955 phase of the study were reported by Thompson (1957). Results of the 1958 evaluation phase are presented herein and are compared with the results of the 1955 pretreatment measurements.

WATERSHED DESCRIPTION

Pleasant Creek watershed lies wholly within Sanpete County, Utah. It is a funnel-shaped area of 21,329 acres, including 854 acres in urban areas and roads; 15,188 acres in privately owned farms and ranches, and 5,287 acres within the Manti-LaSal National Forest. National forest lands occupy the entire headwater portion of the watershed except 200 acres.

Pleasant Creek, the major stream within the watershed, has five principal tributaries: Coal Fork, Dry Pole Fork, Straight Fork, Blue Slide Fork, and North Fork. These tributaries all head at the crest of the Wasatch Plateau, which lies directly east of the town of Mt. Pleasant. They join near the base of the plateau to form Pleasant Creek which flows westerly for 10 miles to its confluence with the Sanpitch River, a tributary of the Sevier River.

Pleasant Creek has flooded approximately twenty times since 1893. Four of these floods caused major damage and seven moderate damage, for an estimated aggregate total damage of \$306,200. All these floods occurred in summer as a result of high intensity precipitation falling on slopes depleted of plant cover. Overgrazing and trampling by livestock were the main causes of depletion. It is an old recurring story well documented not only for Pleasant Creek but for many other high mountain watersheds in the Intermountain region.

Four major vegetal zones occur in this watershed: juniper-pinyon, mountain brush, aspen-fir, and subalpine. Annual precipitation increases with elevation, averaging 12 to 15 inches in the juniper-pinyon zone from its lower to upper limits, 15 to 22 inches in the mountain brush zone, 22 to 30 inches in the aspen-fir zone, and 30 to 33 inches in the subalpine zone (Lull and Ellison, 1950). Most of the precipitation in all zones falls as snow.

Juniper-pinyon zone.--Utah juniper (Juniperus osteosperma), Colorado pinyon (Pinus edulis), and singleleaf pinyon (P. monophylla) dominate this zone, forming a band of low trees along the lower elevations of the foothills up to about 6,500 feet.

Mountain brush zone.--Elevations within this zone range from 6,500 to 7,800 feet. Vegetation is dominated by shrubs, mainly Gambel oak (Quercus gambeli), interspersed with openings that contain a variety of grasses, forbs, and subshrubs.

Aspen-fir zone.--In this zone, which ranges in elevation from 7,800 to 9,500 feet, vegetation consists of coniferous forest on the northerly and easterly slopes; quaking aspen (Populus tremuloides) with an understory of grasses, forbs, and shrubs on the more exposed warmer and drier slopes; and open areas with a grass-forb-shrub mixture. Aspen stands provide one of the most productive forage types because of their lush understory.

Subalpine zone.--This zone includes all of the watershed above 9,500 feet. Vegetation is of two general types: coniferous forest and herbaceous communities. The coniferous type consists principally of Engelmann spruce (Picea engelmanni) and alpine fir (Abies lasiocarpa), and occurs as rather dense forests on steep northerly exposures and as small islands of trees on high ridges and open hillsides. Herbaceous communities are the most extensive plant types of the subalpine zone. Composition varies greatly from place to place; large areas are dominated by slender wheatgrass (Agropyron trachycaulum) and Letterman needlegrass (Stipa lettermani), while smaller areas are dominated by forbs such as sweetsage (Artemisia discolor) and sticky geranium (Geranium viscosissimum). Most of the damaging floods originated in herbaceous communities that had deteriorated as a result of abusive grazing during the past 80 years.

UPSTREAM TREATMENT MEASURES

Headwater areas of the Pleasant Creek watershed are the most critical from a flood hazard standpoint. Intensive treatments were planned and applied to all accessible portions of the subalpine zone, approximating 1,400 acres. Treatments planned included diskplowing, contour trenching, artificial seeding, roadside erosion control, gully stabilization, fencing, and deferred and controlled grazing. Work began in 1954 in Dry Pole Fork of Pleasant Creek and continued until 1957 when all tributaries had been treated.

Dry Pole Fork was plowed on the contour with Brushland plows. A heavy Towner-Meyer two-way diskplow was used in the other drainages. This equipment plowed to a depth of 6 to 10 inches, sufficient to eliminate most of the residual vegetation. Bulldozers were used to construct contour trenches 20 to 30 inches deep and 10 feet wide at the top; they were spaced approximately 90 feet apart vertically. Trenches of this size were designed to retain water from a 2-inch storm.

Plowed areas were seeded by a mechanical broadcaster mounted on the back of the plow, and trenches were broadcast seeded by hand. All areas were seeded at the rate of 14 pounds per acre with a mixture consisting of 7 pounds of smooth brome (Bromus inermis), 3 pounds of orchardgrass (Dactylis glomerata), 2 pounds of timothy (Phleum pratense), 1 pound of meadow foxtail (Alopecurus pratensis), and 1 pound of tall oatgrass (Arrhenatherum elatius).

STUDY OBJECTIVES

Objectives of the evaluation study are to determine the effects of the restoration treatments on:

- a. Channel erosion
- b. Sediment production
- c. Ground cover density
- d. Herbage production by species
- e. Infiltration and soil stability.

To achieve these objectives required the measurement of these factors on transects and plots in 1955 before treatment, and followup remeasurements in 1958, 3 years after treatment. Evaluation measurements were confined to the portion of the subalpine zone that was artificially restored in 1955 and to the mountain brush and juniper-pinyon zones on private land where planned reduction in grazing intensity was expected to bring about natural improvement.

(Field data upon which this evaluation is based are on file at the Great Basin Research Center, Ephraim, Utah.)

CHANNEL EROSION

Channel sites below treated and untreated slopes were measured to determine the effects of upstream slope treatments on channel stability. Three sites suitable for observation of channel cross sections were located below a treated slope area in North Blue Slide Fork, and two others below a nontreated area in North Twin Creek. Sections in untreated North Twin Creek are to serve as controls for evaluating the effects of slope treatment on the channel sections in North Blue Slide Fork. Channel cross sections were marked and outlined with white cotton rope to facilitate photographing and making profile measurements consisting of top and bottom width, and depth, length, and slope of sides. Other observations recorded included character and condition of the channel bottom and sides and kinds of plant covering.

North Blue Slide Fork.--Although some bank sloughing and movement of channel bottom materials occurred, the three sections located in this drainage below a treated slope changed little in 3 years. Bank sloughing widened the main channel cross section 1 foot at the top, and the channel cut one-half foot deeper in the bottom during this 3-year period. Slopes of both sides of the channel showed some improvement in stabilization as plant cover improved (figs. 1 and 2).

Channel cross sections located on the other two tributaries of the North Blue Slide Fork show changes similar to those of the main channel section.

North Fork Twin Creek.--The two channel sections located below an untreated slope showed increases of 4 feet in width at the top and more than 1 foot in depth. Active erosion is now greater on slopes of both sides of this channel than in 1955, not only at this examination site but generally throughout its length. Figure 3 shows the channel as it was in 1955 when the section was located. Figure 4, photographed in 1958, illustrates the accelerated erosion of the channel slopes.

The other channel section, located on a lateral tributary to North Fork Twin Creek, flooded in 1957 because of excessive overland flow from the untreated slope above. Figure 5 shows the appearance of this channel in 1958.

These observations indicate that treatment of slopes above channels can reduce channel erosion in as few as 3 years. This is demonstrated by the contrasting channels below treated and untreated areas.

SEDIMENT PRODUCTION

To determine the effects of intensive rehabilitation treatments on sediment produced in the subalpine zone by its natural climate, six 1-acre sediment plots were located on gullied sites. Two plots were subjected to each of three different treatments: plowed and seeded; plowed, contour-trenched, and seeded; and contour-trenched and trenches seeded. Each plot was divided in half up and down the slope, one half being treated, the other half left untreated.

A contour trench was constructed along the upper and lower boundaries of all plots; the upper trench prevents entry of any outside runoff. The trench at the lower edge of each plot was constructed to catch runoff and sediment originating on the plot. Check dams were placed in the trenches at the corners and center of each plot. Where the treatment included contour trenching, two additional contour trenches were constructed across the treated plots.

The six sediment plots are located on south-, southwest-, and west-facing slopes of 8 to 45 percent gradient (table 1). Sediment eroded from the 1/2-acre plots was determined as the difference in profile measurements of the lower trench of each plot in the spring of 1956 after they had settled and again in 1958.



Figure 1.--View to the northwest of the channel cross section site located in the main channel of the North Fork of Blue Slide Canyon (1955).

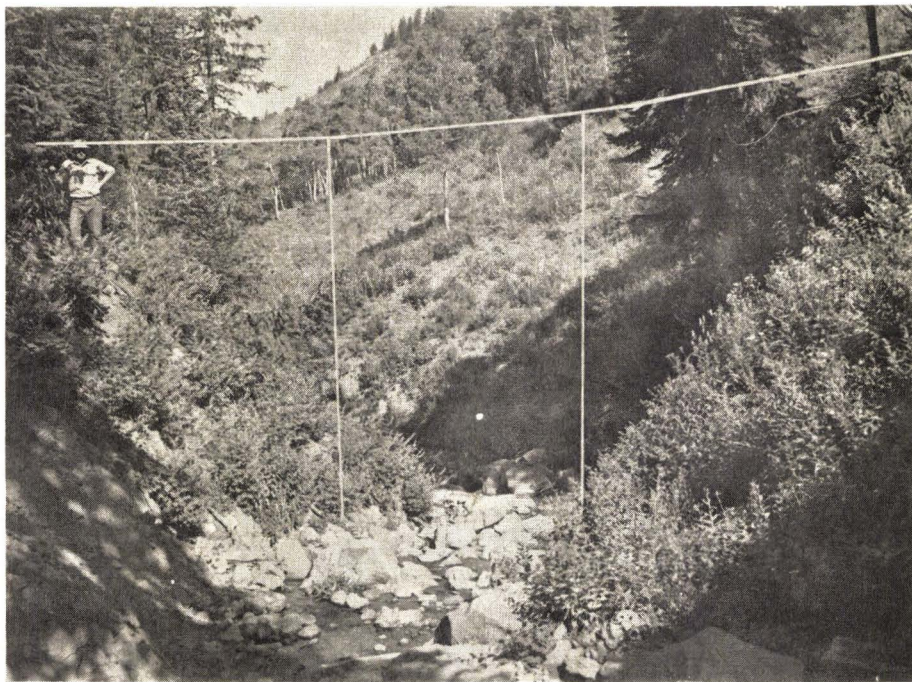


Figure 2.--View of the same Blue Slide Canyon channel section site 3 years later (1958).



Figure 3.--View to the west of the channel cross section site located in the main channel of North Fork Twin Creek Canyon (1955).



Figure 4.--The same Twin Creek channel cross section site 3 years later (1958).



Figure 5.--View to the north of a tributary channel of the North Fork Twin Creek. This channel cross section site in 1955 was 12 feet deep and 6 feet wide at the bottom. Three years later, the channel was 4 feet deep and 19 feet wide at the bottom.

Sediment production for the period 1956-58 on the plots that were disk-plowed was slightly higher (13.55 T/A) than on the untreated control plots (11.05 T/A). Diskplowing, by its disturbance of soil, temporarily increased the opportunity for surface soil movement under intense rainfall, but this increase can be controlled and prevented from entering channels if the slopes are protected by contour trenches.

Closely spaced trenches in the experimental plots divide the plots into narrow segments. Comparisons of sediment production on trenched versus untrenched plots are not presented here because they would not be valid. The function of trenches is to destroy small gully patterns and restrict overland flow and sediment to the trench basins within the confines of the plot. These trenches have functioned properly. They have effectively controlled overland flow and eliminated sedimentation in lower channels.

Table 1.--Plot characteristics and applied treatments on six subalpine zone sediment plots

Plot number	Aspect	Slope	Soil depth	Treatment ^{1/}
		<u>Percent</u>	<u>Inches</u>	
1	West	18	27	Disk plowed
2	West	23	2/12	Disk plowed and contour trenched
3	South	45	(3/)	Contour trenched
4	South	35	28	Contour trenched
5	Southwest	15	22	Disk plowed and contour trenched
6	West	8	30	Disk plowed

^{1/} All disturbed soil was seeded.

^{2/} Abundant surface rock.

^{3/} Extremely shallow and rocky.

GROUND COVER DENSITY AND HERBAGE PRODUCTION

Density and composition of the ground cover on the twelve 1/2-acre sediment plots in the subalpine zone were determined on three parallel and equally spaced 100-foot Parker transects (Parker, 1951) on each plot. Green weight herbage production by species was determined by the method described by Frischknecht and Plummer (1949) on three 9.6 square-foot circular plots located along each transect line at the 25-, 50-, and 75-foot intervals.

In addition to the transects on the sediment plots, 24 Parker transects were established at the same time and distributed as follows: 12 in the subalpine zone on areas that were artificially restored later in 1955, 9 in the mountain brush zone, and 3 in the juniper-pinyon zone. Total herbage production (green weight) and herbage production by individual species were determined by estimating the weight of the herbage on two 9.6 square-foot circular plots located at the 33- and 66-foot points on each transect.

Subalpine Zone

Live plant cover has improved on both the treated and untreated 1/2-acre plots (table 2). Average live plant cover density on the untreated plots increased from 43 percent to 58 percent for an increase of 15 percent in 3 years. This increase is attributed to release from grazing pressure. Average live plant cover increased slightly more on the treated plots, from about 35 percent in 1955 to about 56 percent in 1958. The most significant change in live plant cover on the treated plots is the large increase in grasses from 2 percent to 17 percent.

Table 2.--Live plant cover conditions on the six 1-acre sediment plots in 1955 and 1958

Plot number	Treated half				Untreated half			
	Grass	Forb	Shrub	Total live cover	Grass	Forb	Shrub	Total live cover
	<u>Percent</u>				<u>Percent</u>			
	<u>1955 (before treatment)</u>							
1	-	-	-	(1/)	2.0	49	0	51
2	1	34	0	35	3.0	48	1	52
3	5	19	0	24	6.0	16	0	22
4	2	37	10	49	.3	47	7	54
5	-	-	-	(1/)	10.0	25	6	41
6	2	29	0	31	4.0	34	0	38
Av.	2.5	29.8	2.5	34.8	4.2	36.5	2.3	43.0
	<u>1958 (after treatment)</u>							
1	20	43	0	63	3.0	61	0	64
2	13	38	0	51	5.0	45	5	55
3	25	29	0	54	13.0	33	0	46
4	8	51	4	63	.3	71	4	75
5	29	18	0	47	10.0	33	9	52
6	5	46	4	55	2.0	54	0	56
Av.	16.7	37.5	1.3	55.5	5.5	49.5	3.0	58.0

1/ Plowed before records could be obtained.

Similar increases in average plant cover density were found on the sub-alpine transects outside the plots. Average plant cover increased from about 42 percent in 1955 to about 64 percent in 1958 (table 3). The increase in average plant cover density was accompanied by a decrease in exposed litter. The decrease in exposed litter is attributed in part to its incorporation into the soil following diskplowing and later to the covering of some litter by live plants.

Although live plant cover density increased on all subalpine transects, herbage production was less in 1958 than in 1955 on both the treated and untreated sediment plots as well as the other transects. Total green weight herbage production on the untreated sediment plots decreased from 2,887 pounds per acre in 1955 to 2,581 pounds per acre in 1958. On the treated sediment plots it decreased from 3,253 pounds per acre to 2,846 pounds per acre. On the transects on treated areas outside the sediment plots it decreased from 3,522 pounds per acre to 3,056 pounds per acre. The reductions are about proportionally equal in all three instances. This lower production in 1958 reflects the effect of an extremely dry summer rather than the effects of the restoration treatment. While the production of forbs decreased, grass production increased from about 250 pounds per acre to about 750 pounds per acre on the treated sediment plots and on the transects on treated areas outside the plots.

Table 3.--Live plant cover conditions on the open-range transects
in 1955 and 1958

Transect number	1955				1958			
	Grass	Forb	Shrub	Total live cover	Grass	Forb	Shrub	Total live cover
	<u>Percent</u>				<u>Percent</u>			
	<u>Subalpine</u>							
1	0	48	0	48	15	45	0	60
2	0	44	0	44	11	62	0	73
3	5	38	0	43	28	34	0	62
4	2	32	0	34	24	25	0	49
5	10	31	0	41	19	31	0	50
6	13	36	1	50	17	63	0	80
7	1	44	0	45	16	50	0	66
8	4	40	0	44	12	51	0	63
9	4	23	0	27	7	45	0	52
10	5	44	0	49	18	63	0	81
11	7	35	0	42	14	54	0	68
12	7	29	0	36	13	48	0	61
Av.	4.8	37.0	0.1	41.9	16.2	47.6	0	63.8
	<u>Mountain Brush-Weedy Openings</u>							
1	0	26	0	26	0	41	0	41
2	0	21	0	21	0	55	0	55
3	0	18	0	18	0	32	0	32
Av.	0	22.7	0	22.7	0	42.7	0	42.7
	<u>Mountain Brush-Oakbrush Interspaces</u>							
4	6	5	4	15	10	10	19	39
5	4	3	3	10	15	14	7	36
6	11	1	5	17	21	16	26	63
Av.	7.0	3.0	4.0	14.0	15.3	13.3	17.3	46.0
	<u>Mountain Brush-Sagebrush Interspaces</u>							
7	0	0	14	14	1	0	51	52
8	0	0	27	27	2	1	44	47
9	7	0	27	34	21	0	48	69
Av.	2.3	0	22.7	25.0	8.0	0.3	47.7	56.0
	<u>Juniper-Pinyon</u>							
1	0	2	0	2	0	5	0	5
2	1	0	0	1	2	0	0	2
3	0	2	0	2	0	5	0	5
Av.	0.3	1.3	0	1.7	0.7	3.3	0	4.0

Mountain Brush Zone

No restoration treatment was applied in this zone. For study purposes this zone was divided into three ecotypes: large weedy openings in the oakbrush, small interspace openings in the oakbrush, and small openings in the sagebrush. Three transects were established on each ecotype.

Weedy openings.--Large weedy openings occur in the upper fringe of the mountain brush zone. They comprise only a small portion of the zone but are important because of their high potential for forage production. Present plant cover is dominated by such low-value forbs as showy goldeneye (Viguiera multiflora), prickly lettuce (Lactuca serriola), prostrate knotweed (Polygonum aviculare), and houndstongue (Cynoglossum officinale). These large openings appear to have been cultivated at one time, but their present poor condition is largely the result of excessive concentration of livestock.

Average live plant cover density on the transects in the weedy openings was about 23 percent in 1955 and 43 percent in 1958 reflecting an increase of 20 percent (table 3). Litter cover density was extremely low, averaging only 9 percent in 1955 and 7 percent in 1958. Herbage production averaged about 3,400 pounds per acre in 1955, but only about 600 pounds per acre in 1958. This drastic decrease in herbage production occurring at the same time that live plant cover density increased is explained by the small number of large heavy plants in 1955 contrasted with numerous young seedlings present in 1958.

Oakbrush interspaces.--The small oakbrush interspaces contain a large variety of plant species, both herbaceous and woody. Average live plant cover density, exclusive of oak overstory increased from 14 percent in 1955 to 46 percent in 1958. Herbage production averaged 1,170 pounds per acre in 1955 and 1,240 pounds per acre in 1958.

Sagebrush interspaces.--The big sagebrush type is located near the lower edge of the mountain brush zone and occupies considerable area at this juncture with the juniper-pinyon zone. Live plant cover in this type more than doubled in 3 years, averaging 25 percent in 1955 and 56 percent in 1958 (table 3). Herbage production averaged 1,960 pounds per acre in 1955 and 1,850 pounds per acre in 1958; most of this was big sagebrush (Artemisia tridentata), a relatively unpalatable species on summer range. Sagebrush production was less in 1958 because of damage by a defoliating moth, Aroga websteri. Should damage continue to be as great in ensuing years, heavy losses in sagebrush production will no doubt occur.

Juniper-Pinyon Zone

Total ground cover on the three Parker method transects averaged 34 percent in 1955 and 25 percent in 1958. Most ground cover consists of leaf cast from the trees. Live plant cover, exclusive of juniper and pinyon overstory, averaged only 2 percent in 1955 and 4 percent in 1958 (table 3). No herbage production samples were taken because there was virtually no measurable production.

INFILTRATION AND SOIL STABILITY

To learn the effects of the treatments on some hydrologic processes, two infiltrometer plots, 12 by 30½ inches in size, were established on representative sites as close as possible to the 24 open-range transects, yet sufficiently far away to avoid disturbing them. Slope, aspect, and soil depth characteristics of these plots are presented in table 4.

Data on soil texture and bulk density were collected in both 1955 and 1958. Soil texture was essentially the same both years in all three zones; the only differences found are due to experimental error. Bulk densities at soil depths of 1 to 2½ inches and 4½ to 6 inches were determined on all infiltrometer plots in 1955 and 1958. Minor changes in bulk density, even on the treated areas in the subalpine zone, are slight and not statistically significant.

Ground cover on each infiltrometer plot was analyzed by the point method (Levy and Madden, 1933), based on observations at 90 points per plot (table 4). Live plant cover and herbage production were measured on the infiltrometer plots primarily to ascertain their influence on infiltration and soil stability. Data obtained on these small 2.5 sq.ft. plots are not as representative of general cover and herbage production conditions as those obtained on the larger and more extensive Parker transects and herbage production plots. The Rocky Mountain infiltrometer (Dortignac, 1951) was used in all field tests of infiltration and soil stability. All plots were prewet with 0.5 inch of simulated rainfall to create uniform moisture conditions in the surface soil. The plots were then covered and left undisturbed for about 24 hours to permit the soil to drain to approximately field capacity. Rainfall was applied at a calibrated rate of 3.6 inches per hour for 50 minutes for a total applied depth of about 3 inches. Rainfall and runoff measurements were taken at 5-minute intervals. All runoff was collected, and after the sediment settled out it was filtered and oven-dried. Infiltration rates by 5-minute intervals were determined by subtracting surface runoff from applied rainfall, and thus these rates may include minor surface detention as well as infiltration. The amount of sediment eroded by 3 inches of applied rainfall was used as an index of soil stability. Infiltration capacity and soil stability on the infiltrometer plots are discussed by zones in the following sections.

Subalpine Infiltrometer Plots

Of the 24 infiltrometer plots studied in 1955, only 14 were accessible to the infiltrometer truck and equipment in 1958. Contour trenches blocked access to the other 10.

The infiltration curves in figure 6 are based on average infiltration rates determined on 14 plots in 1955 and 1958. Restoration treatments increased the initial infiltration capacity but decreased final infiltration capacity. The higher initial infiltration capacity probably results from increased depression storage caused by diskplowing and increased interception by the more abundant live plant cover. Reduction in the final infiltration

Table 4.--Live plant cover conditions on infiltrometer plots, 1955 and 1958

Plot number	1955				1958			
	Grass	Forb	Shrub	Total live cover	Grass	Forb	Shrub	Total live cover
	Percent				Percent			
				Subalpine				
1-1	0	22	0	22	7	25	0	32
1-2	0	50	0	50	2	45	0	47
2-1	0	27	0	27	15	51	0	66
2-2	0	32	0	32	4	69	0	73
3-1	0	21	0	21	0	17	0	17
3-2	0	24	0	24	0	69	0	69
4-1	9	12	0	21	16	24	0	40
4-2	1	21	0	22	52	28	0	80
5-1	7	23	0	30	3	53	0	56
5-2	6	47	0	53	43	36	0	79
11-1	5	14	0	19	16	18	0	34
11-2	1	19	0	20	1	30	0	31
12-1	2	5	0	7	12	27	0	39
12-2	0	19	0	19	10	47	0	57
Av.	2.2	24.0	0	26.2	12.9	38.5	0	51.4
				Mountain Brush-Weedy Openings				
1-1	0	24	0	24	0	40	0	40
1-2	0	8	0	8	0	26	0	26
2-1	0	4	0	4	0	21	0	21
2-2	0	10	0	10	0	21	0	21
3-1	0	6	0	6	0	16	0	16
3-2	0	8	0	8	0	16	0	16
Av.	0	10.0	0	10.0	0	23.3	0	23.3
				Mountain Brush-Oakbrush Interspaces				
4-1	1	3	0	4	21	3	0	24
4-2	8	0	0	8	11	4	0	15
5-1	4	2	0	6	6	8	0	14
5-2	2	2	0	4	26	1	0	27
6-1	11	0	0	11	6	2	3	11
6-2	20	0	0	20	36	2	3	41
Av.	7.7	1.2	0	8.8	17.7	3.3	1.0	22.0
				Mountain Brush-Sagebrush Interspaces				
7-1	0	0	3	3	1	4	9	14
7-2	0	0	3	3	2	0	0	2
8-1	0	0	0	0	0	1	0	1
8-2	0	0	3	3	3	17	0	20
9-1	0	0	1	1	32	0	3	35
9-2	7	0	0	7	0	1	0	1
Av.	1.2	0	1.7	2.8	6.3	3.8	2.0	12.2
				Juniper-Pinyon				
1-1	0	0	0	0	0	0	0	0
1-2	0	0	0	0	0	0	0	0
2-1	0	8	0	8	3	0	0	3
2-2	0	0	0	0	0	0	0	0
3-1	0	1	0	1	0	0	0	0
3-2	0	0	0	0	0	2	0	2
Av.	0	1.5	0	1.5	0.5	0.3	0	0.8

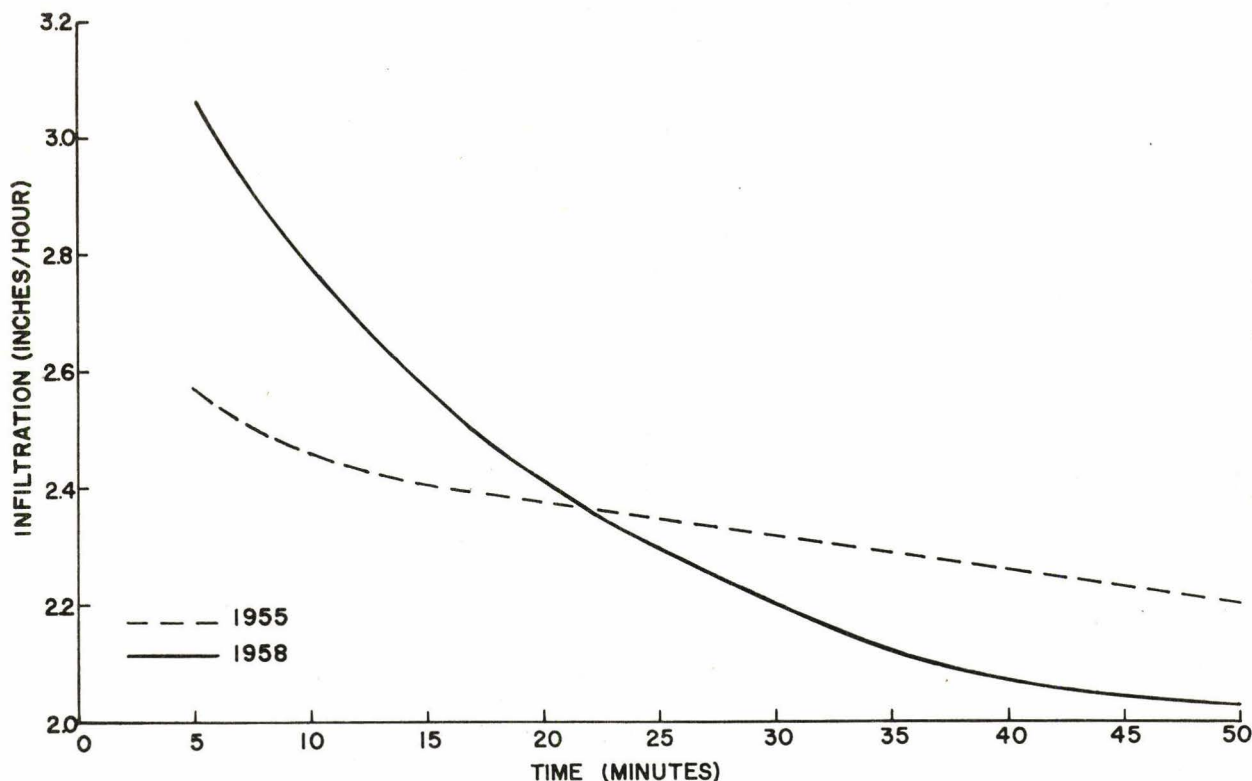


Figure 6.--Average infiltration rates for 14 plots in the subalpine zone before and after treatment.

capacity is attributed to increased puddling of the soil by raindrop impact following the partial breakdown of soil structure by diskplowing.

Sediment eroded by 3 inches of artificial rainfall was much greater in 1958 than in 1955, although total runoff did not increase significantly. The average sediment production on the subalpine infiltrometer plots caused by an applied rainfall of 3.0 inches at a rate of 3.6 in./hr. was 0.41 ton per acre in 1955 compared to 1.62 tons per acre in 1958. This fourfold increase indicates that the soil can be more easily eroded in the first few years following treatment because treatments such as diskplowing naturally loosen the soil and make it more easily transportable. Nevertheless the higher initial infiltration capacity coupled with the contour trenches provide reasonable assurance that overland flow derived from natural rainfall will be slight, and in the absence of appreciable overland flow, serious erosion will not occur. The soil is expected to become more stable as its structure improves under the protective influence of plant cover and litter.

Mountain Brush Infiltrometer Plots

A total of 18 infiltrometer plots was established on 3 sites in this zone: 6 in a large weedy opening, 6 in oakbrush interspaces, and 6 in sagebrush interspaces. The plots are on west, southwest, northwest, and north aspects having slope gradients varying from 7 to 18 percent (table 4).

Weedy openings.--Infiltration rates did not change significantly, but initial infiltration rates (during the first 10 minutes) tended to be higher and final infiltration rates were generally lower. Total runoff did not change significantly, but sediment eroded by 3 inches of applied rain almost doubled, averaging 2.85 tons per acre in 1955 and 5.15 tons per acre in 1958. Trampling by livestock prior to measurements in 1958 and the dry condition of the surface soil are believed to be the main factors that caused this increase.

Oakbrush interspaces.--In 1958 initial infiltration capacity had decreased appreciably and final infiltration was only about half as much as it was in 1955. Sediment eroded from the infiltrometer plots by 3 inches of applied rain increased from 2.09 tons per acre in 1955 to 2.55 tons per acre in 1958 and this is attributed to increased runoff from the applied rainfall.

Sagebrush interspaces.--Both initial and final infiltration capacities in 1958 showed slight increases over those in 1955 and now equal or exceed those in the other two mountain brush ecotypes. Although overland flow decreased slightly, sediment eroded by 3 inches of applied rain increased slightly from 2.15 tons per acre to 2.49 tons per acre.

Juniper-Pinyon Infiltrometer Plots

Six infiltrometer plots were established in this zone in openings between the trees. They were located on east-, south-, and west-facing slopes ranging from 3 to 16 percent (table 5).

Infiltration rates were slightly higher in 1958 than in 1955 but are still far below the minimum required to prevent damaging overland flow during intense summer storms. Sediment eroded by 3 inches of applied rain declined from an average of 4.57 tons per acre in 1955 to 3.66 tons per acre in 1958 because of a reduction in total runoff.

Juniper and pinyon trees provide good aerial cover for about one half of the area, but the interspaces must be classed as critical from the standpoint of watershed management.

Table 5.--Slope, aspect, and soil depth characteristics of
infiltrometer plots

Transect: Plot : Soil number :number:Slope:Aspect:depth					Transect: Plot : Soil number :number:Slope:Aspect:depth				
<u>Percent</u> <u>Inches</u>					<u>Percent</u> <u>Inches</u>				
<u>Subalpine-N. Fk. Blue Slide</u>					<u>Mt. Brush-Weedy Openings</u>				
1	1	15	SW	10	1	1	11	W	20
1	2	13	SW	24	1	2	7	W	24
2	1	20	S	24	2	1	16	W	10
2	2	19	S	24	2	2	18	W	8
3	1	19	S	31	3	1	12	W	32
3	2	15	S	32	3	2	13	W	24
4	1	19	W	16	Av.		13		20
4	2	13	W	10					
5	1	12	W	30	<u>Mt. Brush-Oakbrush Interspaces</u>				
5	2	10	W	36	4	1	15	SW	6
Av.		16		24	4	2	18	SW	8
<u>Subalpine-S. Fk. Blue Slide</u>					5	1	10	NW	10
6	1	15	SW	22	5	2	14	NW	8
6	2	18	SW	17	6	1	8	NW	12
7	1	18	S	15	6	2	11	N	14
7	2	18	S	50	Av.		13		10
8	1	15	SW	15	<u>Mt. Brush-Oakbrush Interspaces</u>				
8	2	25	SW	24	7	1	16	SW	10
9	1	23	W	51	7	2	10	SW	24
9	2	18	W	20	8	1	11	W	20
10	1	25	W	29	8	2	12	W	22
10	2	21	W	14	9	1	10	W	20
Av.		20		26	9	2	10	W	40
<u>Subalpine-Straight Fork</u>					Av.		11		21
11	1	14	SW	39	Av. all		12		17
11	2	7	SW	33	<u>Juniper-Pinyon</u>				
12	1	13	SW	37	1	1	11	E	
12	2	8	SW	67	1	2	3	E	
Av.		10		44	2	1	10	S	
Av. all		15		31	2	2	10	S	
					3	1	16	W	
					3	2	10	W	
					Av.		10		

CONCLUSIONS

This study covers only the first 3-year evaluation period following treatments on the Pleasant Creek watershed, much of which has undergone complete alteration of cover. Because of the short period involved, results reported must be considered tentative. Repeat measurements scheduled for 1961 are expected to reveal more clearly the long-time effects of artificial restoration.

Channel erosion has been reduced by artificial restoration of depleted slopes in the subalpine zone. Contour trenches are primarily responsible for this improvement because the herbaceous cover has not yet developed sufficiently to control overland flow adequately.

Sediment production during the first 3 years after artificial restoration was slightly greater on plots that were diskplowed and seeded but less on plots that were contour trenched and not diskplowed than on untreated plots. Contour trenches are providing effectively the needed flood control while the seeded grasses become established and the soil becomes restabilized.

In 3 years since artificial restoration, density of live plant cover in the subalpine zone has increased to about $1\frac{1}{2}$ times its pretreatment density. Seeded grasses have increased more than native forbs. Litter cover density was reduced by diskplowing and has not yet built up to its original level, but proper management will likely cause it to increase beyond its original density in a few years.

Herbage production on the artificially restored subalpine area was less in 1958 than in 1955 before treatment. This decrease should not be construed as a result of adverse effects of artificial restoration; rather, it is due to the extreme dryness of the summer, which reduced herbage production over the entire area.

Diskplowing and contour trenching destroyed many small shoestring gullies extending down the slope. These treatments formed numerous detention depressions along the slope in opposition to the up-and-down slope gully pattern, and thus eliminated most of the rapid gully drainage and reduced overland flow.

Artificial restoration has increased initial infiltration but decreased final infiltration. However, studies at the station's field research center at Ephraim, Utah, of the behavior of summer storms showed that their highest intensity usually occurs within the first few minutes. During such storms, higher initial infiltration is of prime importance.

Results from the infiltrometer studies indicate that diskplowing has temporarily decreased stability of the surface soil. However, this condition is not serious so long as overland flow is kept in check by contour trenches while vegetation increases in density. Soil stability and final infiltration capacity should increase as the soil structure improves.

Although considerably more plant cover was present in the openings and interspaces of the mountain brush zone in 1958 than in 1955, this zone generally is yet far below its potential productivity of palatable forage, and most of the openings and interspaces are critical flood source areas. Soil stability and infiltration are much too low to prevent further deterioration by accelerated erosion. Only the presence of unpalatable brush has prevented this zone from becoming a serious flood source area. Artificial restoration measures similar to those employed in the subalpine zone probably would halt deterioration and increase usable forage.

The juniper-pinyon zone is in even worse condition. Virtually no usable forage is produced. Although juniper and pinyon trees are fairly dense, the areas between them are almost bare and are eroding badly. This zone also could support a good ground cover, but competition by the trees and continued abusive grazing prevent establishment of such a cover.

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